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True RMS Meter

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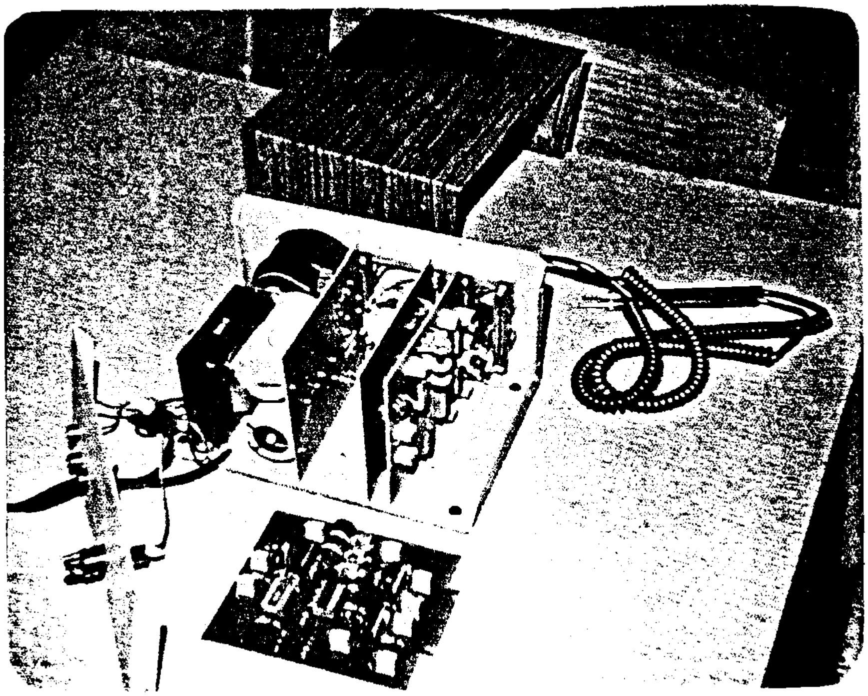
by Rodney Springer



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ABSTRACT

Measuring devices that will indicate when an alternating current signal is equal to the direct current which will produce the same average heating effect in a given resistance are needed in the electrical field. The root-mean-square (rms) value of a waveform is used for this purpose. The rms value of a waveform can be found by using either the thermal heating properties of the signal, or by some type of mathematical computation.

The mean-absolute-deviation (mad) value technique of converting the rms value of a waveform to its dc equivalent is the most popular, but it will work for only one specific type of input signal. Thermal rms-dc conversion is a very accurate technique, but it is usually quite expensive. Implicit computation rms-dc conversion is possible but it has its disadvantages. Direct computation rms-dc conversion is a very straightforward technique that squares the input signal, averages it, and then square-roots it to preform the rms-dc conversion.

To build the squaring and square-rooting units of the direct computation rms-dc converter, analog multipliers are needed. It has only been within the past five years that the technology necessary to produce accurate and low cost analog multipliers has come about. Of the seven most popular techniques for building analog multipliers, the logarithmic sum technique is the most straightforward. The logarithmic sum analog multiplier applies the input signals to two logarithmic amplifiers. The signals from the logarithmic amplifiers are fed into a summing circuit and from here are applied to the input of an antilogarithmic amplifier.

The basic logarithmic or antilogarithmic amplifier uses a resistor and a transistor combination in conjunction with an operational amplifier to preform the logarithmic or antilogarithmic conversion. But these basic circuits suffer so heavily from errors, especially due to temperature variation that they are of very little practical use. Practical logarithmic and antilogarithmic amplifiers use special operational amplifiers and two transistors to offset the errors encountered with the basic circuit.

Once the specifications for the system were set and the types of logarithmic and antilogarithmic amplifiers that were to be used in the project were chosen, the actual building of the system could begin. Six separate units are necessary to build the "True RMS Meter" using the direct computation rms-dc conversion technique with logarithmic sum analog multipliers. These units are Input Processing, Squaring, Averaging, Square-Rooting, Readout, and the Power Supply.

The Input Processing unit scales the input signal to the system for proper readout ranges, and full-wave rectifies the signal to be seen by the Squaring unit so the range of operation of the Squaring unit can be extended from single to 2-quadrant operation. The Squaring unit is a logarithmic sum analog multiplier with the inputs tied together. The logarithmic and antilogarithmic amplifiers used in the Squaring unit are respectively Intersil ICL 8048 and ICL 8049 integrated circuits. A constant current source applies a reference current to each logarithmic and antilogarithmic amplifier, while a noninverting summing circuit is used to sum the voltages from the logarithmic amplifiers in the analog multiplier. The Averaging that is used in the "True RMS Meter" is a running average, not the ideal time integration technique. The running average is preformed by using a simple RC low-pass filter. The Square-Rooting operation is preformed by merely placing a Squaring unit in the feedback loop of a high gain operational amplifier. The Readout element that was used was a 0-10 volt dc panel meter, while a regulated $\pm$ 15 volt dc Power Supply was used to apply bias voltage to the integrated circuits in the project.

Performance tests were conducted to determine the actual characteristics of the "True RMS Meter." These system performance tests and tests on individual units that have been included in Appendix C indicate that the final system meets the original specifications set for the project.